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Research article

INFLUENCE OF PHOSPHORUS, SULPHUR AND BORON ON GROWTH, YIELD, NUTRIENT UPTAKE AND ECONOMICS OF RAPESEED (*Brassica Campestris* L. VAR. YE LLOW SARSON)

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ABSTRACT: A field experiment comprising three levels each of phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1}) and sulphur (0, 20 and 40 kg S ha^{-1}) and two levels of boron (0 and 1 kg B ha^{-1}) was conducted during the winter seasons for two consecutive years of 2007-08 and 2008-09 at farmers field of Pingla block in Pashcim Medinipur district of West Bengal to study the contribution of these nutrients in improving yield components and yield of rapeseed crop [*Brassica campestris var yellow sarson*] cv. 'B-9' on medium deep loam soil having medium in available P and S. The experiment was carried out in a factorial randomised block design with three replications. The results revealed that successive increase in P, S and B levels increased yield attributes and seed yield of yellow sarson crop. The increase in seed yield was significant up to 60 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} while uptake of P and S was significant up to 60 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1}. Seed-yield response to tested different levels of P and S was found quadratic. Based on the response equation, optimum dose of P_2O_5 was 48.1 kg ha^{-1} and response was 8.3 kg seeds kg^{-1} P_2O_5. Corresponding figures for S application were 27.3 kg S ha^{-1} and 13.5 kg seed kg^{-1} S. Net returns were the maximum with 60 kg P_2O_5 ha^{-1} (Rs 40852.75 ha^{-1}) and 20 kg S ha^{-1} (Rs 38477 ha^{-1}), whereas benefit: cost ratio was the highest with 30 kg P_2O_5 ha^{-1} (2.87) and 20 kg S ha^{-1} (2.48). Boron application also recorded marked improvement in seed yield (14.38%), uptake of P (12.75%), S (12.78%) and net returns (13.9%) and benefit: cost ratio (7.11) as compared to control.
Key words: Rapeseed, *Brassica campestris var yellow sarson*, Phosphorus, Sulphur, Boron, Nutrient uptake, Economics

INTRODUCTION

Rapeseed-mustard occupies important position among oilseed crops grown in India. In eastern India, especially in southern parts of West Bengal, where winter is relatively short and mild, rapeseed is preferred by the farmers because with one or two life saving irrigation but the area has not explored potential yield of this crop because of suboptimal use of nutrients. Yield potentials of the crop can be realized by providing plant nutrients in balanced amount along with suitable agronomic package and practices. Besides nitrogen and phosphorus, sulphur also limits the productivity of this crop. The response of rapeseed–mustard to P and S is determined by moisture availability, soil P and S status and yield level. Phosphorus (P) plays an indispensable role within the energy storage and transfer in the form of AMP, ADP, ATP, NADP or $NADPH_2$. It also promotes root development and enlargement [1], affect seed germination, cell wall division, flowering, fruiting, synthesis of fat, starch and in fact most biochemical activities like amino acid synthesis. Application of P and S is also important in increasing the efficacy of other nutrients.

Rapeseed-mustard crops are particularly sensitive to sulphur deficiency mainly due to the fact that S plays an important role in the chemical composition of seed and increases the percentage of oil content of seed [2]. It (S) plays an important role in metabolism of rapeseed-mustard plant as a component of proteins and formation of flavouring compounds known as glucosinolates [3]. Glucosinolates are preformed resistance barriers contributing general plant defence mechanism [4]. Recent advances in B research have greatly improved an understanding for B uptake and transport processes [5, 6, 7], and roles of B in cell wall formation [8] (O'Neill *et al.*, 2004), cellular membrane functions and anti-oxidative defense systems [9]. Boron deficiency is a worldwide problem for field crop production where significant crop losses occur both in yield and quality [10]. It plays an important role in translocation of photosynthates and growth regulators from source to sink and growth of pollen grains thereby marked increase in seed yield of crops [11]. Boron is involved in the synthesis of protein and oil [12]. Hence an attempt was made to study the effect of P, S and B on growth and yield attributes and seed yield of rapeseed under irrigated conditions

MATERIALS AND METHODS

The experiment was conducted during the winter seasons of 2007–2009 at farmer's field of Pingla block in Pashcim Medinipur district of West Bengal on medium deep loamy soil having pH 5.31. The soil was low in organic carbon (0.39%) and medium-low in available phosphorus (20.4 kg P_2O_5/ha). The experiment was laid out in a factorial randomised block design having 3 levels of phosphorus (0, 30 and 60 kg P_2O_5/ha), 3 levels of sulphur (0, 20 and 40 kg S/ha) and 2 levels of boron (0 kg and 1kg B/ha). As per treatment, full dose of phosphorus, sulphur and boron along with 2/3 rd of recommended dose of nitrogen and 2/3rd of potassium was applied before sowing by drilling in furrows. Remaining 1/3rd dose of nitrogen and potassium were applied at 30 days after sowing. The crop was sown after harvest of *kharif* rice on desired soil moisture that was achieved through light irrigation. Yellow sarson cv. 'B-9 (Benoy)' was sown in rows 30 cm apart on 25th November and harvested on 10 th and 8 th February during 2007–2008 and 2008–2009 respectively. The crop received one hand-weeding at 20 days after sowing and 2 sprays of insecticides + fungicide in the last week of December. The thinning was carried out at 20 days after sowing (DAS) to have optimum plant stand. Apart from pre-sowing irrigation, two irrigations were given during end of branching and the other at seed filling stage. The crop received 4.31 and 0.012 mm rainfall during the crop growing peroid of 2007–2008 and 2008–2009 respectively. Quadratic equation ($Y=a+bx\pm cx^2$) was fitted to arrive at economic optimum dose. P and S uptake in seed were estimated by multiplying respective content with seed yield.

RESULTS AND DISCUSSION

Growth attributes

The P, S and B significantly increased the growth parameters of rapeseed crop (Table 1). Application of 60 kg P_2O_5/ha had significantly increased plant height and dry matter of plants/m^2 over its other levels. Highest leaf area index (LAI) and crop growth rate (CGR) were achieved with only 30 kg P_2O_5/ha. Obviously control treatment (0 kg P_2O_5/ha) recorded significantly lowest values of all growth attributes. Similarly different S levels showed increase in values of different growth attributes over its control. This might be due to increased supply of P and S which helped the crop to increase photosynthesis and hasten different physiological activities and metabolic processes related to its growth. Application of boron @ 1 kg B ha^{-1} also resulted into a significant increase in different growth attributes like plant height, dry matter accumulation, LAI and CGR over control.

Yield attributes

Application of 60 kg P_2O_5/ha recorded significant increase in number of branches/plant, siliquae/plant, 1000-seed weight, whereas seeds/siliqua showed marked increase only up to 30 kg P_2O_5/ha over the control in both the years and on pooled basis (Table-2). Similar trend of increasing yield attributes of rapeseed (cv. B-9) was observed with S. Such a response to increasing P and S levels might be ascribed to adequate supply of these nutrients that resulted in higher production of photosynthates and their translocation to sink. These findings are in close conformity with those of Aulakh *et al*. [13]. Application of B (1kg/ha) had also resulted marked increase in siliquae/plant, seeds/siliqua and 1,000-seed weight compared with the control (Table-2). This might be because of the role of boron in fertility improvement and translocation of photosynthates. These results are in close conforming to those of Bhilegaonkar *et al.* [14], Chander *et al.* [15] and Nadian *et al.* [16]. Ahmed Khan *et al.* [17] also reported increase in yield attributes of some oilseed crops like sunflower, sesame and Indian mustard with the boron application at seed-filling stage.

Seed yield, Stover yield and Seed oil content

Positive responses of P, S and B application on growth and yield attributes further got reflected on the seed yield, stover yield and oil content of seeds (Table 2). It is evident from the table that successive increase in rate of phosphorus from 0 to 60 kg P_2O_5/ha has shown corresponding increase in yield of yellow sarson crop in both the years and on pooled basis. The increase in seed yields with 30 and 60 kg P_2O_5/ha was 36.17and 41.67% respectively over the control. These results are in close conformity to those of Pasricha *et al*. [18], Ahmad *et al*. [19] and Rana *et al.* [20]. Similarly sulphur application also increased the seed and stover yields over its subsequent level, but the difference between 20 and 40 kg S/ha was not significant. The increase in seed yields at 20 and 40 kg S/ha over the control was 28.78 and 29.96% respectively. The enhancement of seed yield in mustard due to the application of sulphur has been reported by Suresh *et al*. [21] and Raut *et al.* [22]. Again the seed and stover yields of yellow sarson increased significantly due to the soil application of Boron and the highest seed and stover yields was obtained from the plots receiving 1 kg B/ha and the lowest yield from the control plots. Similar to seed yield, the seed oil content also recorded significant improvement with P, S and B application up to 60 kg P_2O_5/ha , 20 kg S/ha and 1 kg B/ha, respectively.

The improvement may be due to the higher concentration of P, S and B positively influencing bio-synthesis of fatty acids. These results are in close conformity with those of Pasricha *et al*. [18] (1987), Ahmad *et al*. [19], Pradhan and Sarkar [23] and Rana *et al.* [20]. The interaction between phosphorus, sulphur and boron was significant on pooled basis. The pooled data revealed that application of 60 kg P_2O_5/ha with 40 kg S/ha and 1 kg B/ha recorded higher seed yield over other interaction components. A significant increase in yield in this treatment combination was observed over control ($P_0xS_0xB_0$) treatment.

Seed nutrient uptake

There was a significant increase in the total P and S uptake owing to application of P, S and B (Table-3). Phosphorus application increased the seed uptake of P and S and the effect was significant up to 60 kg P_2O_5/ha. With subsequent increase in P_2O_5 level from 0 to 60 kg/ha, the increase was 97.6 and 9.4% in P_2O_5 uptake, 68.2 and 9.5% in S uptake. With the increase in S level from 0 to 40 kg S/ha, there was an improvement in the P and S uptake, but the margin between successive level was significant up to 20 kg S/ha. Boron application induced marked increase in the uptake of P and S. This increased in P and S uptake could be credited to variation in the availability of these nutrients in the soil and partly due to priming effect of one nutrient on the other. Rana *et al.* [20] reported similar effect of nutrient application on the uptake.

Response equation

The response of seed yield to phosphorus and sulphur application was worked out by fitting response equation and following estimated equation for phosphorus and sulphur were obtained from seed yield data over 2 years.

Phosphorus: $Y = 940.03 + 16.16 (P_2O_5) - 0.161(P_2O_5)^2$

Sulphur: $Y = 990 + 21.5 S - 0.35 (S)^2$

These equation revealed that response to phosphorus and sulphur was quadratic, and the optimum dose of P and S was 48.13 kg and 27.35 kg/ha respectively. The response per kg P and S at optimum dose in terms of seed yield was 8.39 and 13.57 kg/ha of P and S.

The crop responded to higher level of P and S under irrigated conditions owing to favourable soil and weather conditions and proper placement of nutrient in the soil profile. The soil was medium deep loam having sufficient capacity to store conserved moisture.

Table 1. Growth attributes of rapeseed as influenced by phosphorus, sulphur and boron (data pooled over 2 years)

Treatment	Heighest LAI (at 40 DAS)	dry matter of plants/m^2(g/m^2) (at 80 DAS)	Heighest CGR(g/m^2/day) (40DAS-60 DAS)
Phosphorus(kg P_2O_5/ha)			
0	1.33	1060.28	21.86
30	1.73	1327.28	26.93
60	1.66	1350.94	26.62
CD(P = 0.05)	0.02	3.04	0.14
Sulphur(kg S/ha)			
0	1.41	1115.81	22.84
20	1.64	1304.92	26.24
40	1.67	1317.78	26.33
CD(P = 0.05)	0.02	3.04	0.14
Boron(kg/ha)			
0	1.53	1187.78	24.11
1	1.62	1304.56	26.17
CD(P = 0.05)	0.01	2.5	0.11
[DAS = Days After Sowing]			

Economics

Returns were calculated from the market price of Rs 4250/q of mustard. The variable cost was calculated from the fertilizer application cost which worked out to be Rs 28.12/kg P_2O_5, Rs 100/kg S and Rs 70/kg borax. Among the P levels, maximum net returns were recorded with 60 kg P_2O_5/ha, whereas benefit: cost ratio was highest with 30 kg P_2O_5/ha. However, among S levels, maximum net returns (Rs 38477) and highest benefit: cost ratio (2.48) were recorded with 20 kg S/ha and 40 kg S/ha respectively. Boron application was superior to the control for net returns and benefit: cost ratio. Such behaviour of economic parameters due to P, S and B levels was due to changes in marginal seed yield of the crop with successive increase in fertilizer nutrient and relative costs of inputs in relation to output.

Table 2. Yield attributes, seed yield, stover yield and seed oil content of rapeseed as influenced by phosphorus, sulphur and boron (data pooled over 2 years)

Treatments	Branches/plant	Siliquae/plant	Seeds/siliqua	1000-Seedweight(g)	Stover Yield (kg/ha)	Seed Yield (kg/ha)	Seed oil content (%)
P_2O_5 (kg/ha)							
0	9.05	77.70	17.64	1.86	1947.50	940.00	38.01
30	10.74	79.64	21.45	2.29	2952.80	1280.00	41.28
60	10.99	82.68	20.51	2.42	3115.30	1331.70	41.99
CD(P = 0.05)	0.03	2.01	0.090	0.02	119.25	50.92	0.50
S (kg /ha)							
0	9.08	76.95	18.07	1.83	2109.45	990.00	39.23
20	10.83	78.21	21.12	2.34	2931.10	1275.00	40.83
40	10.87	84.85	20.41	2.40	2975.00	1286.70	41.22
CD(P = 0.05)	0.03	2.01	0.090	0.02	119.25	50.92	0.50
B (kg/ha)							
0	9.93	75.96	18.88	2.00	2447.40	1104.45	40.14
1	10.59	84.05	20.86	2.38	2896.30	1263.30	40.71
CD(P = 0.05)	0.02	1.64	0.08	0.015	97.36	41.57	0.41

Table 3. Seed Nutrient uptake and economics of rapeseed as influenced by phosphorus, sulphur and boron (data pooled over 2 years)

Treatment **P_2O_5 (kg/ha)**	Seed nutrient uptake (kg/ha)		Net return (Rs/ha)	benefit: cost ratio
	P	S		
0	7.64	8.82	27201.25	2.17
30	15.1	14.84	40189.5	2.87
60	16.52	16.25	40852.75	2.63
CD (P = 0.05)	0.589	0.579		
S (kg /ha)				
0	10.67	10.47	28360.25	2.10
20	14.1	14.49	38477	2.48
40	14.49	14.96	36974.25	2.11
CD (P = 0.05)	0.589	0.579		
B (kg/ha)				
0	12.31	12.51	33225.75	2.46
1	13.88	14.11	39396.42	2.86
CD (P = 0.05)	0.481	0.473		

CONCLUSION AND RECOMMENDATION

Successive increase in P, S and B levels increased the yield attributes and seed yield of yellow sarson crop on medium deep loamy soil of Pashcim Medinipur district of West Bengal.

Significant increase in seed yield was recorded up to 60 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1}. Seed-yield response to tested different levels of P and S was quadratic. Response equation revealed the optimum dose of P_2O_5 is 48.1 kg ha^{-1} and 27.3 kg S ha^{-1}. Boron application @ 1 kh ha^{-1}also increase about 15% seed yield, and uptake of P and S to the extent of 12.75% and 12.78%, respectively. Maximum net returns were recorded with 60 kg P_2O_5 ha^{-1} (Rs 40852.75 ha^{-1}) and 20 kg S ha^{-1} (Rs 38477 ha^{-1}) whereas the highest benefit: cost ratio was registered with 30 kg P_2O_5 ha^{-1} (2.87) and 20 kg S ha^{-1} (2.48). Results revealed that application of P, S and B besides N and K would be remunerative one for oilseeds in southern parts of West Bengal.

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